

# **APPENDIX A**

## CURRICULUM VITAE

Name: Carl O. Pabo

Born: September 1, 1952  
Rochester, New York

Address: Sangamo BioSciences, Inc.  
Point Richmond Tech Center  
501 Canal Blvd., Suite A100  
Richmond, CA 94804

Telephone: (510) 970-6000 x216  
Fax: (510) 236-8951  
Email: cpabo@sangamo.com

Education: Yale College  
New Haven, Connecticut  
B.S., Molecular Biophysics and Biochemistry 1974

Harvard University  
Cambridge, Massachusetts  
Ph.D., Biochemistry and Molecular Biology 1980

Positions: Postdoctoral Fellow  
Department of Biochemistry and Molecular Biology  
Harvard University 1980-1982

Assistant Professor  
Department of Biophysics  
Johns Hopkins University School of Medicine 1982-1986

Associate Professor  
Department of Molecular Biology and Genetics and  
Department of Biophysics  
Johns Hopkins University School of Medicine 1986-1990

Associate Investigator  
Howard Hughes Medical Institute 1986-1991

Professor  
Department of Molecular Biology and Genetics and  
Department of Biophysics  
Johns Hopkins University School of Medicine 1990-1991

Professor  
Department of Biology  
Massachusetts Institute of Technology 1991-2001

Investigator  
Howard Hughes Medical Institute 1991-2001

Investigator  
Center for Cancer Research  
Massachusetts Institute of Technology 1999-2001

Senior Vice President and Chief Scientific Officer  
Sangamo BioSciences, Inc. 2001-

Awards:

- Elected to Phi Beta Kappa, 1973
- Graduated *summa cum laude*, 1974
- NSF Predoctoral Fellowship, 1974-1977
- Jane Coffin Childs Memorial Fund  
Postdoctoral Fellowship, 1980-1982
- American Cancer Society Junior Faculty  
Research Award, 1983-1985
- Protein Society Young Investigator Award, 1991
- Pfizer Award in Enzyme Chemistry, 1992
- Elected to American Academy of Arts and Sciences, 1993
- Elected to National Academy of Sciences, 1998

## PUBLICATIONS

1. Pabo, C.O., Sauer, R.T., Sturtevant, J.M. & Ptashne, M. (1979) The  $\lambda$  Repressor Contains Two Domains. **Proc. Natl. Acad. Sci., USA** **76**, 1608-1612.
2. Sauer, R.T., Pabo, C.O., Meyer, B.J., Ptashne, M. & Backman, K.C. (1979) The Regulatory Functions of the  $\lambda$  Repressor Reside in the Amino-Terminal Domain. **Nature** **279**, 396-400.
3. Johnson, A.D., Pabo, C.O. & Sauer, R. T. (1980) Bacteriophage  $\lambda$  Repressor and Cro Protein: Interactions with Operator DNA. **Meth. Enz.** **65**, 839-856.
4. Ptashne, M., Jeffrey, A., Johnson, A.D., Mauer, R., Meyer, B.J., Pabo, C.O., Roberts, T.M. & Sauer, R.T. (1980) How the  $\lambda$  Repressor and Cro Work. **Cell** **19**, 1-11.
5. Pabo, C.O., Krovatin, W., Jeffrey, A. & Sauer, R.T. (1982) The N-Terminal Arms of  $\lambda$  Repressor Wrap Around the Operator DNA. **Nature** **298**, 441-443.
6. Pabo, C.O. & Lewis, M. (1982) The Operator-Binding Domain of  $\lambda$  Repressor: Structure and DNA Recognition. **Nature** **298**, 443-447.
7. Sauer, R.T., Yocum, R.R., Doolittle, R.F., Lewis, M. & Pabo, C.O. (1982) Homology Among DNA-Binding Proteins Suggests Use of a Conserved Super-Secondary Structure. **Nature** **298**, 447-451.
8. Ptashne, M., Johnson, A.D. & Pabo, C.O. (1982) A Genetic Switch in a Bacterial Virus. **Scientific American** **247**, 128-140.
9. Lewis, M., Jeffrey, A., Wang, J.-H., Ladner, R.C., Ptashne, M. & Pabo, C.O. (1983) Structure of the Operator-Binding Domain of  $\lambda$  Repressor: Implications for DNA Recognition and Gene Regulation. **Cold Spring Harbor Symp. Quant. Biol.** **47**, 435-440.
10. Gussin, G., Johnson, A.D., Pabo, C.O. & Sauer, R.T. (1983) Repressor and Cro. **Lambda II** (J. Roberts, ed.) Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, 93-121.

11. Ohlendorf, D.H., Anderson, W.F., Lewis, M., Pabo, C.O. & Matthews, B.W. (1983) Comparison of the Structures of Cro and  $\lambda$  Repressor Proteins from Bacteriophage  $\lambda$ . **J. Mol. Biol.** **169**, 757-769.
12. Sauer, R.T. & Pabo, C.O. (1983) Protein-DNA Recognition: The  $\lambda$  Repressor-Operator Complex. **American Society for Microbiology News** **49**, 131-136.
13. Pabo, C.O. (1983) Designing Proteins and Peptides. **Nature** **301**, 200.
14. Pabo, C.O., Jordan, S.R. & Frankel, A.D. (1983) Systematic Analysis of Possible Hydrogen Bonds Between Amino Acid Side Chains and B-Form DNA. **J. Biomolecular Structure and Dynamics** **1**, 1039-1049.
15. Sauer, R.T. & Pabo, C.O. (1984) How  $\lambda$  Repressor Binds Operator DNA. **Microbiology** **1984**.
16. Pabo, C.O. & Sauer, R.T. (1984) Protein-DNA Recognition. **Ann. Rev. Biochem.** **53**, 293-321.
17. Pabo, C.O. (1984) DNA-Protein Interactions. **Proceedings of the Robert A. Welch Foundation Conferences on Chemical Research XXVII Stereospecificity in Chemistry and Biochemistry** Robert A. Welch Foundation, Houston, TX, 222-255.
18. Lewis, M., Wang, J. & Pabo, C.O. (1985) Structure of the Operator Binding Domain of  $\lambda$  Repressor. **Biological Macromolecules and Assemblies, Volume 2** (Drs. Jurnak & McPherson, eds.) John Wiley and Sons, Inc., New York, 266-287.
19. Jordan, S.R., Pabo, C.O., Vershon, A.K. & Sauer, R.T. (1985) Crystallization of the Arc Repressor. **J. Mol. Biol.** **185**, 445-446.
20. Jordan, S.R., Whitcombe, T.V., Berg, J.M. & Pabo, C.O. (1985) Systematic Variation in DNA Length Yields Highly Ordered Repressor-Operator Co-Crystals. **Science** **230**, 1383-1385.
21. Pabo, C.O. & Suchanek, E.G. (1986) Computer-Aided Model-Building Strategies for Protein Design. **Biochemistry** **25**, 5987-5991.
22. Sauer, R.T., Hehir, K., Stearman, R.S., Weiss, M.A., Jeitler-Nilsson, A., Suchanek, E.G. & Pabo, C.O. (1986) An Engineered Intersubunit Disulfide Enhances the Stability and DNA Binding of the N-Terminal Domain of  $\lambda$  Repressor. **Biochemistry** **25**, 5992-5998.
23. Weiss, M.A., Pabo, C.O., Karplus, M. & Sauer, R.T. (1986) Dimerization of the Operator-Binding Domain of Phage  $\lambda$  Repressor. **Biochemistry** **26**, 897-904.
24. Pabo, C.O. (1987) Introductory chapter for **Protein Engineering** (D. L. Oxender & C. F. Fox, eds.) Alan R. Liss, Inc., New York, xv-xvii.
25. Berg, J.M., Jordan, S.R. & Pabo, C.O. (1987) The Structure and Function of Bacteriophage  $\lambda$  Repressor. **DNA: Protein Interactions and Gene Regulation** (E.B. Thompson & J. Papaconstantinou, eds.) University of Texas Press, Austin, 1-12.
26. Pabo, C.O. (1987) New Generation Databases for Molecular Biology. **Nature** **327**, 467.
27. Frankel, A.D., Berg, J.M. & Pabo, C.O. (1987) Metal-Dependent Folding of a Single Zinc Finger from Transcription Factor IIIA. **Proc. Natl. Acad. Sci., USA**

84, 4841-4845.

28. Frankel, A.D., Bredt, D.S. & Pabo, C.O. (1988) Tat Protein from Human Immunodeficiency Virus Forms a Metal-Linked Dimer. **Science** **240**, 70-73.
29. Frankel, A.D. & Pabo, C.O. (1988) Fingering Too Many Proteins. **Cell** **53**, 675.
30. Frankel, A.D., Chen, L., Cotter, R.J. & Pabo C.O. (1988) Dimerization of the Tat Protein from HIV: A Cysteine-Rich Peptide Mimics the Normal Metal-Linked Dimer Interface. **Proc. Natl. Acad. Sci., USA** **85**, 6297-6300.
31. Stearman, R.S., Frankel, A.D., Freire, E., Liu, B. & Pabo, C.O. (1988) Combining Thermostable Mutations Increases the Stability of  $\lambda$  Repressor. **Biochemistry** **27**, 7571-7574.
32. Jordan, S.R. & Pabo, C.O. (1988) Structure of the  $\lambda$  Complex at 2.5 Å Resolution: Detailed View of the Repressor-Operator Interactions. **Science** **242**, 893-899.
33. Frankel, A.D. & Pabo, C.O. (1988) Cellular Uptake of the Tat Protein from Human Immunodeficiency Virus. **Cell** **55**, 1189-1193.
34. Sauer, R.T., Jordan, S.R. & Pabo, C.O. (1990)  $\lambda$  Repressor: A Model System for Understanding Protein-DNA Interactions and Protein Stability. **Adv. Prot. Chem.** **40**, 1-61.
35. Bowie, J.U., Clarke, N.D., Pabo, C.O. & Sauer, R.T. (1990) Identification of Protein Folds: Matching Hydrophobicity Patterns of Sequence Sets with Solvent Accessibility Patterns of Known Structures. **Proteins** **7**, 257-264.
36. Pabo, C.O., Aggarwal, A.K., Jordan, S.R., Beamer, L.J., Obeysekare, U. & Harrison, S.C. (1990) Conserved Residues Make Similar Contacts in Two Repressor-Operator Complexes. **Science** **247**, 1210-1213.
37. Liu, B., Kissinger, C.R., Pabo, C.O., Martin-Blanco, E. & Kornberg, T.B (1990) Crystallization and Preliminary X-ray Diffraction Studies of the Engrailed Homeodomain and of an Engrailed Homeodomain/DNA Complex. **Biochem. and Biophys. Res. Comm.** **171**, 257-259.
38. Kissinger, C.R., Liu, B., Martin-Blanco, E., Kornberg, T.B. & Pabo, C.O. (1990) Crystal Structure of an Engrailed Homeodomain/DNA Complex at 2.8 Å Resolution: A Framework for Understanding Homeodomain/DNA Interactions. **Cell** **63**, 579-590.
39. Wolberger, C., Pabo, C.O., Vershon, A.K. & Johnson, A.D. (1991) Crystallization and Preliminary X-ray Diffraction Studies of a MAT $\alpha$ 2-DNA Complex. **J. Mol. Biol.** **217**, 11-13.
40. Pavletich, N.P. & Pabo, C.O. (1991) Zinc Finger-DNA Recognition: Crystal Structure of a Zif268-DNA Complex at 2.1 Å. **Science** **252**, 809-817.
41. Wolberger, C. Vershon, A.K., Liu, B., Johnson, A.D. & Pabo, C.O. (1991) Crystal Structure of a MAT $\alpha$ 2 Homeodomain-Operator Complex Suggests a General Model for Homeodomain-DNA Interactions. **Cell** **67**, 517-528.
42. Clarke, N.D., Beamer, L.J., Goldberg, H.R., Berkower, C. & Pabo, C.O. (1991) The DNA Binding Arm of  $\lambda$  Repressor: Critical Contacts from a Flexible Region. **Science** **254**, 267-270.
43. Godley, L., Pfeifer, J., Steinhauer, D., Ely, B., Shaw, G., Kaufmann, R., Suchanek, E., Pabo, C., Skehel, J.J., Wiley, D.C. & Wharton, S. (1992) Introduction of Intersubunit Disulfide Bonds In the Membrane-Distal Region of the Influenza

Hemagglutinin Abolishes Membrane Fusion Activity. **Cell** **68**, 635-645.

44. Pabo, C.O. & Sauer, R.T. (1992) Transcription Factors: Structural Families and Principles of DNA Recognition. **Annu. Rev. Bi chem.** **61**, 1053-1095.
45. Beamer, L.J. & Pabo, C.O. (1992) Refined 1.8 Å Crystal Structure of the  $\lambda$  Repressor-Operator Complex. **J. Mol. Bi** **1**, 227, 177-196.
46. Pavletich, N.P. & Pabo, C.O. (1993) Crystal Structure of a Five Finger GLI-DNA Complex: New Perspectives on Zinc Fingers. **Science** **261**, 1701-1707.
47. Pavletich, N.P., Chambers, K.A. & Pabo, C.O. (1993) The DNA-Binding Domain of p53 Contains the Four Conserved Regions and the Major Mutation Hot Spots. **Genes & Development** **7**, 2556-2564.
48. Rebar, E.J. & Pabo, C.O. (1994) Zinc Finger Phage: Affinity Selection of Fingers with New DNA-Binding Specificities. **Science** **263**, 671-673.
49. Raumann, B.E., Rould, M.A., Pabo, C.O. & Sauer, R.T. (1994) DNA Recognition by  $\beta$ -sheets in the Arc Repressor-Operator Crystal Structure. **Nature** **367**, 754-757.
50. Klemm, J.D., Rould, M.A., Aurora, R., Herr, W. & Pabo, C.O. (1994) Crystal Structure of the Oct-1 POU Domain Bound to an Octamer Site: DNA Recognition with Tethered DNA-Binding Modules. **Cell** **77**, 21-32.
51. Ma, P.C.M., Rould, M.A., Weintraub, H. & Pabo, C.O. (1994) Crystal Structure of MyoD bHLH Domain-DNA Complex: Perspectives on DNA Recognition and Implications for Transcriptional Activation. **Cell** **77**, 451-459.
52. Nekludova, L. & Pabo, C.O. (1994) Distinctive DNA Conformation with Enlarged Major Groove Is Found in Zn Finger-DNA and Other Protein-DNA Complexes. **PNAS** **91**, 6948-6952.
53. Clarke, N.D., Kissinger, C.R., Desjarlais, J., Gilliland, G.L., & Pabo, C.O. (1994) Structural Studies of the Engrailed Homeodomain. **Prot. Sci.** **3**, 1779-1787.
54. Pomerantz, J.L., Sharp, P.A., & Pabo, C.O. (1995) Structure-Based Design of Transcription Factors. **Science** **267**, 93-96.
55. Xu, W., Rould, M.A., Jun, S., Desplan, C., & Pabo, C.O. (1995) Crystal Structure of a Paired Domain-DNA Complex at 2.5 Å Resolution Reveals Structural Basis for Pax Developmental Mutations. **Cell** **80**, 639-650.
56. Pomerantz, J.L., Pabo, C.O., & Sharp, P.A. (1995) Analysis of Homeodomain Function by Structure-Based Design of a Transcription Factor. **PNAS** **92**, 9752-9756.
57. Klemm, J.D. & Pabo, C.O. (1996) Oct-1 POU Domain-DNA Interactions: Cooperative Binding of Isolated Subdomains and Effects of Covalent Linkage. **Genes & Development** **10**, 27-36.
58. Rebar, E.J., Greisman, H.A., & Pabo, C.O. (1996) Phage Display Methods for Selecting Zinc Finger Proteins with Novel DNA-Binding Specificities. **Methods In Enzymology** **267**, 129-149.
59. Elrod-Erickson, M., Rould, M.A., Nekludova, L., & Pabo, C.O. (1996) Zif268 Protein-DNA Complex Refined at 1.6 Å: A Model System for Understanding Zinc Finger-DNA Interactions. **Structure** **4**, 1171-1180.
60. Greisman, H.A. & Pabo, C.O. (1997) A General Strategy for Selecting High-Affinity

Zinc Finger Proteins for Diverse DNA Target Sites. **Scienc** 275, 657-661.

61. Kim, J.-S., Kim, J., Cepek, K.L., Sharp, P.A., & Pabo, C.O. (1997) Design of TATA Box-Binding Protein/Zinc Finger Fusions for Targeted Regulation of Gene Expression. **PNAS** 94, 3616-3620.
62. Tucker-Kellogg, L., Rould, M.A., Chambers, K.A., Ades, S.E., Sauer, R.T., & Pabo, C.O. (1997) Engrailed (Gln 50 -> Lys) Homeodomain-DNA Complex at 1.9 Å Resolution: Structural Basis for Enhanced Affinity and Altered Specificity. **Structure** 5, 1047-1054.
63. Kim, J.-S. & Pabo, C.O. (1997) Transcriptional Repression by Zinc Finger Peptides. **J. Biol. Chem.** 272, 29795-29800.
64. Pomerantz, J.L., Wolfe, S.A., & Pabo, C.O. (1998) Structure-Based Design of a Dimeric Zinc Finger Protein. **Biochemistry** 37, 965-970.
65. Kim, J.-S. & Pabo, C.O. (1998) Getting a Handhold on DNA: Design of Poly-Zinc Finger Proteins with Femtomolar Dissociation Constants. **PNAS** 95, 2812-2817.
66. Elrod-Erickson, M., Benson, T.E., & Pabo, C.O. (1998) High-Resolution Structures of Variant Zif268-DNA Complexes: Implications for Understanding Zinc Finger-DNA Recognition. **Structure** 6, 451-464.
67. Fraenkel, E. & Pabo, C.O. (1998) Comparison of X-ray and NMR Structures for the Antennapedia Homeodomain-DNA Complex. **Nature Struct. Bio.** 5, 692-697.
68. Fraenkel, E., Rould, M.A., Chambers, K.A., & Pabo, C.O. (1998) Engrailed Homeodomain-DNA Complex at 2.2 Å Resolution: A Detailed View of the Interface and Comparison with Other Engrailed Structures. **J. Mol. Biol.** 284, 351-361.
69. Wolfe, S.A., Greisman, H.A., Ramm, E.I., & Pabo, C.O. (1999) Analysis of Zinc Fingers Optimized Via Phage Display: Evaluating the Utility of a Recognition Code. **J. Mol. Biol.** 285, 1917-1934.
70. Zheng, N., Fraenkel, E., Pabo, C.O., & Pavletich, N.P. (1999) Structural Basis of DNA Recognition by the Heterodimeric Cell Cycle Transcription Factor E2F-DP. **Genes & Development** 13, 666-674.
71. Xu, H.E., Rould, M.A., Xu, W., Epstein, J.A., Maas, R.L., & Pabo, C.O. (1999) Crystal Structure of the Human Pax6 Paired Domain-DNA Complex Reveals Specific Roles for the Linker Region and Carboxy-terminal Subdomain in DNA Binding. **Genes & Development** 13, 1263-1275.
72. Ohndorf, U.-M., Rould, M.A., He, Q., Pabo, C.O., & Lippard, S.J. (1999) Basis for Recognition of Cisplatin-Modified DNA by High-Mobility-Group Proteins. **Nature** 399, 708-712.
73. Elrod-Erickson, M., & Pabo, C.O. (1999) Binding Studies with Mutants of Zif268: Contribution of Individual Side Chains to Binding Affinity and Specificity in the Zif268 Zinc Finger-DNA Complex. **J. Biol. Chem.** 274, 19281-19285.
74. Wang, B.S., & Pabo, C.O. (1999) Dimerization of Zinc Fingers Mediated by Peptides Evolved *in vitro* from Random Sequences. **PNAS** 96, 9568-9573.
75. Chasman, D., Cepek, K., Sharp, P.A., & Pabo, C.O. (1999) Crystal Structure of an OCA-B Peptide Bound to an Oct-1 POU Domain/Octamer DNA Complex: Specific Recognition of a Protein-DNA Interface. **Genes & Development** 13, 2650-

76. Wolfe, S.A., Nekludova, L., & Pabo, C.O. (2000) DNA Recognition by Cys<sub>2</sub>His<sub>2</sub> Zinc Finger Proteins. **Annual Review of Biophysics and Biomolecular Structure** **29**, 183-212.
77. Grant, R.A., Rould, M.A., Klemm, J.D., & Pabo, C.O. (2000) Exploring the Role of Glutamine 50 in the Homeodomain-DNA Interface: Crystal Structure of Engrailed (Gln50 → Ala) Complex at 2.0 Å. **Biochemistry** **39**, 8187-8192.
78. Wolfe, S.A., Ramm, E.I., & Pabo, C.O. (2000) Combining Structure-Based Design with Phage Display to Create New Cys<sub>2</sub>His<sub>2</sub> Zinc Finger Dimers. **Structure** **8**, 739-750.
79. Joung, J.K., Ramm, E.I., & Pabo, C.O. (2000) A Bacterial Two-Hybrid Selection System for Studying Protein-DNA and Protein-Protein Interactions. **PNAS** **97**, 7382-7387.
80. Pabo, C.O., & Nekludova, L. (2000) Geometric Analysis and Comparison of Protein-DNA Interfaces: Why Is There No Simple Code for Recognition? **J. Mol. Biol.** **301**, 597-624.
81. Pabo, C.O., Peisach, E., & Grant, R.A. (2001) Design and Selection of Novel Cys<sub>2</sub>His<sub>2</sub> Zinc Finger Proteins. **Annual Review of Biochemistry** **70**, 313-340.
82. Wang, B.S., Grant, R.A., Pabo, C.O. (2001) Selected Peptide Extension Contacts Hydrophobic Patch on Neighboring Zinc Finger and Mediates Dimerization on DNA. **Nature Struct. Bio.** **8**, 589-593.
83. Wolfe, S.A., Grant, R.A., Elrod-Erickson, M., & Pabo, C.O. (2001) Beyond the "Recognition Code": Structures of Two Cys<sub>2</sub>His<sub>2</sub> Zinc Finger/TATA Box Complexes. **Structure** **9**, 717-723.
84. Miller, J.C., & Pabo, C.O. (2001) Rearrangement of Side-chains in a Zif268 Mutant Highlights the Complexities of Zinc Finger-DNA Recognition. **J. Mol. Biol.** **313**, 309-315.



Amgen/ Genentech  
015260 241

**Do Not Use!**

This binder contains a portion of the uncorrected, Larry Gold Expert Report (01/20/03).

Refer to the 01/27/03 Corrected First Expert report of Larry Gold, Ph.D.